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LABOR MARKET RETURN TO COMPUTER SKILLS: USING MICROSOFT CERTIFICATION TO MEASURE COMPUTER SKILLS[†]

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Abstract

Using data from a Microsoft survey and the Current Population Survey, we examine the returns to Microsoft Certification in early 2000's. The formal structure of Microsoft Certification provides a well documented external measure of computer skills rather than the ad-hoc self reports used in other research. We find that the wage premium for MS certification may be over 30% in the full labor market. When certificate holders are compared to only individuals in IT occupations, the overall wage premium falls to a range of 3-7%. We find that the hierarchical structure of Microsoft Certification is reflected in the wage premium associated with specific certificates, further supporting the claim that these certificates measure skills valued in the labor market. We also find that different IT occupations have different values for these skills. The similarity between the return to certification and the return to general education is examined.

JEL classification: J 24; J30; J31
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I. Introduction

The expansion of information technology (hereafter IT) use during the 1990's has impacted labor markets in myriad ways. It has been observed, both casually and through more rigorous investigation, that the average wage of those who use computers on the job is substantially higher compared to those who don't use computers on the job even after controlling for personal, occupational, and industry characteristics (Krueger, 1993; Doms et al., 1997; Autor et al., 1997 and Green, 1999). Krueger (1993) estimated the wage premium to computer use at work using the Current Population Survey. His findings suggested that workers who use computers at their work earn 10 to 15 percent more than non-users. Autor et al. (1997) found that skill biased technological change has effected educational returns and generally increased the wage dispersion.

Though Krueger (1993) estimated a variety of models trying to control for possible omitted variables, the paper became heavily criticized by DiNardo and Pischke (1997). Following his approach, they found a similar wage differential to the use of calculators, telephones, and even pencils. They argued that Krueger's results just reflected the fact that higher paid (more productive) workers used computers on their jobs. DiNardo and Pischke (1997) suggest that on-the-job use of a computer requires specific skills. Workers possessing these skills earn higher wages and are allocated to jobs in which computers are used. It may be that these skills are particularly evident among more productive workers. A positive correlation between introduction of computers and upgrading skills requirements was found both on the firm and industry levels (e.g. Groot and De Grip, 1991; Autor et al. 2000 and Fernandez, 2001). Those findings suggested that a computer use wage premium being related to skills is a reasonable hypothesis. In general, use of computers may be associated with higher skilled workers. This paper examines the return to a specific set of skills: computer skills themselves.

There is substantial evidence that the computer use premium reflects a wage premium for skills. Autor et al. (1997) argue that the changes in the return to education reflect skill biased technological change, the adoption of technology that is complimentary to labor force skills. Levy and Murnane (1992) and Bresnahan et al. (1999) found that computer use is associated with a higher level of specific skills which indirectly affect earnings. Entorf and Kramarz (1996), using panel data, have shown that computers are first introduced to higher-paid (more able) workers. Cappelli and Carter (2000) found that the positive wage premium associated with computer use declines and often becomes insignificant when various controls for human capital are added into the model. Krashinsky (2000) studied the return to computer use with data on identical twins and found that the computer wage premium goes down from 20% to 7% and becomes insignificant once inter-twin ability controls are introduced into the analysis.

Like the return to education, the return to the types of skills associated with computer use measures the value of human capital. Unlike education, it is a more specific human capital assessment and as such sheds light on the implications of skill biased technological change and the value of human capital. A few authors have attempted to measure the return to computer skills directly. Hamilton (1997) found 13-25% computer wage premium using familiarity with software packages and programming languages as a measure of computer skills. However, Borghans and ter Weel (2001) showed that while there is a 20-30% wage premium for computer skills, the premium does not vary with the level of skills. Only for highly-skilled workers with an advanced level of sophistication of computer use did Borghans and ter Weel (2001) find a positive premium for computer skills. In Borghans and ter Weel (2004) a wage premium to computer use is found to vary from 24% to 74% while no significant effects are found for computer skills when both are controlled for.

Despite the different conclusions, these papers faced the same problem: how to evaluate computer skills. While Hamilton (1997) focused on quantitative measures such as at least one instance of encountering different software and programming languages, Borghans and ter Weel (2001, 2004) made an attempt to address the quality dimension, relying on self-assessed skills. While innovative and somewhat informative, the approach used by both of these authors entails ad hoc or self reported measures of both skills and quality. These measures have come under criticism since they result in categorization that raises questions. For example, using the approach employed by Borghans and ter Weel (2001, 2004), we interviewed both economics professors and department secretaries.

Each group described computers as being essential to their job. Further, both groups characterized themselves as having high skills. The sophistication measure varied for these two as being complex and moderate respectively. In such a situation, the "sophistication" question may, in fact, reveal the skills requirements level, while the "skills level" question may reflect the worker's job qualification with respect to computer skills. Taking into account a high correlation between the level of computer users' effectiveness and the levels of sophistication at which computers are being used in the data it is no surprising that wage premium to various computer skills is found insignificant when skills and use levels are both controlled for. Hamilton, in contrast, characterized database administrators and musicians who use Microsoft Excel spreadsheets for their personal needs in the same group. Clearly, these measures may not reflect the measures that theory would require.

In order to measure the return to computer skills or human capital, a measure of those skills is necessary. One such measure is the hierarchical system of Microsoft Certification. Since these certifications are internationally standardized they provide a unique measure of computer skills. The hierarchical structure of this certification standard allows us to estimate the return to different types and levels of computer skills. Data from the Microsoft Corporation are combined with data from the Current Population Survey. The CPS data does not contain measures of MS certification, and so measurement error is present in this variable. We exploit the asymmetric structure of the measurement error and known population certification rates to address this issue. We examine the return to certification in the general population and in population of individuals in IT occupations. The IT sample controls for common characteristics associated with computer use and further isolates the effects of certification specifically. The hierarchical structure allows us to examine different levels of certification, similar to different levels of educational attainment.

II. Certification in IT Sector and the Role of Microsoft

In modern business, IT certification in general and Microsoft certification in particular has been an important phenomenon for all parties involved since 1990s. As skill validation, certification "ensures that businesses are able to identify experts who know how to use those powerful tools and solutions to the best of their advantage"[1]. For the workers, certification is not only associated with a higher human capital but also can provide signals about leadership qualities and comprehension of innovative information. It is also a several billion dollar a year business. According to a study conducted by International Data Corporation, the IT training and testing industries reached $2.5 billion in 1999 (IDC, 2000). Though not formally required in the IT sector, certification may result in brand loyalty or provide additional market power for the certifying company.

Certification exams and certification requirements are typically designed by a vendor. For example, Microsoft, Cisco, and Novell each have their own certification programs and tests. Some of them are more general; others are very product- or subject-oriented. Each vendor typically provides several certificates that may be obtained if one has successfully passed a certain number of exams. For example, to obtain Microsoft Certified Professional certificate (hereafter MCP), one needs to pass a single test; while to become a Microsoft Certified Systems Engineer (MCSE), one is required to pass five core exams (four operating system exams and one design exam), plus two elective exams. In many cases certificates have to be renewed after two or three years. There are also some certification programs that are considered "vendor-neutral." They have been designed by a third party or a group rather than a single vendor. The most celebrated examples are Brainbench and CompTIA certificates.

The Microsoft Certified Professional Program was established in 1992. In the year 2000, Fairfield Research, Inc. and Certification Magazine recognized Microsoft as the industry leader whose certification programs attracted the largest number of certificates. According to www.microsoft.com, as of January 2004 about 1.5 million individuals had achieved Microsoft certification worldwide, and about one third of them obtained more than one certificate. While several other vendors and vendor-neutral organizations had issued their own credentials, the number of their certificants is much smaller then the number of Microsoft certified professionals. As estimated, in August 2001 there were no more then 400,000 CompTIA certificants, less then 400,000 Novell certificants, and about 30,000 to 50,000 Cisco and Oracle certification holders worldwide. Other certification programs accounted for even smaller shares. At the same time several

1 http://www.microsoft.com/learning/mcp/benefits/hire.asp, visited February, 2004.

studies[2] conducted around 1999-2001 suggest that individuals with other credentials often hold corresponding MS certificates. This all together implies that Microsoft certification is a good proxy of corresponding skills. At the same time, one needs to keep in mind that the observed return to MS certification can at least in part be attributed to other credentials held by the same individual.

Several business studies[3] held in 2000-2002 reported the return to Microsoft certification around 10%-12%. Surprisingly, in academic research certification of IT specialists has not received a lot of attention. Though the number of salary surveys of certified IT professionals and IT-related specialists has grown over recent years, there have been no academic studies examining IT certification.

III. The Data

The data for this research derive from two sources. The first data set was provided by Microsoft Certified Professional Magazine. The Microsoft sample consists of more than 6,000 Microsoft certified IT professionals. The questionnaire includes a detailed set of questions eliciting information on salary, benefits, job characteristics, certification, and standard demographic characteristics comparable to those in the Current Population Survey. The Microsoft data provide a set of individuals who have received certificates. Additional data are taken from the March 2001 Current Population Survey. March 2001 was chosen since the earnings information in the Microsoft data refer to the year 2000. CPS data are a mixture of individuals with and without certificates; however, for these observations the certification variable is unobserved. We combine those two sources to construct data sets to be used in estimation. The full CPS and MS samples were pooled together to construct a data set for our study, the "Full sample". The MS sample and the IT subsample of CPS made up another data set, called "IT sample".

A. The CPS Samples

From the March 2001 CPS, full-time year-round workers with non-negative earnings and complete data were selected. A subsample of workers in information

2 See for example, Adelman, 2000 or Gabelhouse, 2001.

3 http://www.certcities.com/editorial/salary_surveys/

technology occupations was also drawn (the IT sample). These occupations were: computer systems analysts and scientists; computer programmers; operations and systems researchers and analysts; computer science teachers (postsecondary education); tool programmers, numerical control; computer operators, peripheral equipment operators, supervisors of the computer equipment operators[4]. Both samples comprise a mixture of certified and non- certified individuals given that some respondents can also be certified Microsoft professionals. However, in practice, we code all observations from the CPS samples as having no certification. This induces measurement error into a dummy right-hand side variable. The estimated coefficients provide a lower bound of the certification impact on earnings (Aigner, 1973; Klepper, 1988; Bollinger 1996). We address this issue by using results from Bollinger (1996) and aggregate information on issued certificates to adjust our estimated coefficients for the measurement error induced by assuming that all CPS observations do not have certification.

B. The Microsoft Sample

The Microsoft data set was collected by Wilson Research Group in 2001 on behalf of Microsoft Certified Professional Magazine. Using every *n*th name from a Microsoft-supplied list of all Microsoft Certified Professionals in the continental U.S., 33,000 respondents were contacted by email and invited to a password-protected web site to complete the survey. The response rate was about 20%. This sample includes only certified individuals. To make the Microsoft data set comparable to our CPS sample, Microsoft respondents who did not answer to the question about their occupation or identified themselves as students or unemployed were excluded.

One concern about MS sample is whether it is representative of the population of Microsoft certificate holders. To be able to derive proper conclusions, it is important to understand to what degree the respondents in this sample are representative of the entire population of Microsoft certified professionals. While it is difficult to ensure this, we examine the distribution of certificates within the sample relative to all certificates granted. We also compare the sample to the CPS IT sample. The MS sample appears to be very similar in most respects to these populations.

4 CPS codes: 064, 229, 065, 129, 308, 233, 309, 304.

In 2000 Microsoft offered eight specific certificates which varied by the field of expertise and also by the skill level. The basic skill level credential is **MCP** (Microsoft Certified Professional). The next skill group is represented by two intermediate level credentials, **MCP+I** (Microsoft Certified Professionals with Internet proficiency) and **MCP+SB** (Microsoft Certified Professionals with Site-building proficiency). And finally, there are five advanced credentials: **MCSE** (Microsoft Certified Systems Engineers), **MCSE+I** (Microsoft Certified Systems Engineers with Internet proficiency), **MCSD** (Microsoft Certified Solution Developers), **MCDBA** (Microsoft Certified Database Administrators), **MCT** (Microsoft Certified Trainers). More details about the specific certificate requirements can be found in the Appendix.

Microsoft certificates can be grouped into four tracks, where skills of a similar type but of a different level are verified. The first track is called "Systems Engineering track" and includes MCP, MCP+I, MCSE and MCSE+I certificates. The second type of skills can be built up along the "Developer track", which includes MCP, MCP+SB and MCSD certificates. The "database administrator track" includes MCP and MCDBA. The MCT certificate, "Certified Trainer", can be obtained after completing the highest certificate in any track. Microsoft describes it as a separate "Trainer" track.

Microsoft publishes the total number of certificates worldwide[5]. Our sample deviates from the distribution of certificates worldwide in one potentially important aspect. Our sample contains a smaller proportion of individuals with only the basic certification. This fact will possibly upwardly bias the overall effect of Microsoft certification. However, when looking at the effect of each single certificate, undersampling of individuals with the basic certificate is not likely to raise concerns. Other groups describe a distribution similar to the actual one. Specifically, the two largest groups consist of individuals holding MCSE and MCP+I. The smallest group includes IT professionals with MCP+SB. Other certificates are approximately equally distributed in the sample as well as in the population. Some difference can also be attributed to the fact that our sample is drawn in the continental USA only.

5 These numbers are available upon request.

C. Variable Definitions and Descriptive Statistics

Following a standard Mincer (1974) model, the natural log of annual earnings is regressed on age, education, and gender[6]. Firm size variables are also included in some specifications since they are likely to be associated with certification. Their effects are measured at midpoints and using a set of dummy variables. Table 1 presents summary statistics for these variables in each of three samples: the Microsoft Sample, the full CPS data and the CPS IT data.

6 The MS data set does not have a race variable, so to make CPS and MS specifications as comparable as possible, we do not include race in the regressions samples.

Table 1. Summary Statistics: MS, Full CPS, and CPS IT samples.

Data Set	Variables	Mean	Std. Dev.	Min.	Max.
Microsoft sample (6572 obs[7])	**Earnings**	61,126.37	24,531	27,500	150,000
	Age	35.15	8.45	16.5	60
	Education	15.18	1.96	10	20
	Female	0.10	0.30	0	1
	Hours[8]	43.21	6.51	20	51
	Firm size	16,011.21	29,378.95	1	100,000
	Self-employed	0.06	0.23	0	1
	Small and medium (0-499)	0.42	0.49	0	1
	Large firm (500-999)	0.08	0.27	0	1
	Extra large (1000+)	0.45	0.50	0	1
Full CPS sample (42909 obs)	**Earnings**	42,761.93	44,045.94	1	511,794
	Age	40.94	11.52	15	90
	Education	13.66	2.46	6	20
	Female	0.42	0.49	0	1
	Hours	43.77	7.96	35	99
	Firm size	511.45	446.96	4.5	1,000
	Self-employed	0.09	0.28	0	1
	Small and medium (0-499)	0.53	0.50	0	1
	Large firm (500-999)	0.06	0.23	0	1
	Extra large (1000+)	0.42	0.49	0	1
CPS IT sample (1087 obs)	**Earnings**	61,319.16	42,953.06	1	454,915
	Age	38.34	9.97	17	76
	Education	15.18	2.12	6	20
	Female	0.31	0.46	0	1
	Hours	43.13	6.43	35	99
	Firm size	706.19	408.74	4.5	1,000
	Self-employed	0.05	0.22	0	1
	Small and medium (0-499)	0.32	0.47	0	1
	Large firm (500-999)	0.06	0.24	0	1
	Extra large (1000+)	0.62	0.49	0	1

For the CPS respondents, **earnings** is calculated as total annual wage and salary plus total own business self-employment earnings. Self-employment earnings are included since IT workers are disproportionately more likely to have additional earnings derived from one-time projects. The Earnings variable for the Microsoft respondents is calculated on the basis of the question “Please select the range that best describes your base personal

7 There are 250 respondents who did not report the firm size of their employer. The average earning for this group is around $53,000 and they are slightly more likely to be females (15%). In all other characteristics these respondents are similar to the rest of the MS sample.

8 There are 324 respondents, whose working hours are coded as part time, most likely due to irregular working pattern. The average earning for this group is around $59,000. In all other characteristics these respondents are similar to the rest of the MS sample. The variable is top-coded at 51 for those who work more than 50 hours a week.

income (salary) before taxes in 2000?" There were 18 such categories. Except for the highest and lowest categories, each had a range of $4000. For respondents whose earnings fall into categories other than the highest and lowest, we assigned earnings as the midpoint of the range. Respondents whose earnings fall into the lowest category, under $30,000, are assigned the values of $27,500. Respondents whose earnings fall into the highest category, over $150,000, are assigned the value of $150,000. The average earnings of the MS respondents were $61,126.37. As one would expect, the average earnings for the IT sample is very comparable at $61,319.16. This provides some evidence that the respondents of the MS sample do not have a markedly higher or lower earnings distribution than other IT workers. As one would expect, however, the earnings of the full CPS sample are lower than those in either the MS or IT sample: $42,761.93.

The average **age** of the respondents in the Microsoft sample is slightly above 35 years, with less than 0.10% of respondents being under 18 years and 0.5% being above 60 years. An average respondent in the CPS IT sample is 3 years older, and an average worker from the full CPS sample is 5 years older. These means are quite close, if we note that 33 workers in the MS sample of the age 60 and above reported their age as 60. Less then 0.5% of individuals in both CPS samples are under 18 years, while about 2% in the CPS IT sample and 5% in the full CPS sample are above 60 years.

In all samples, the education variable (EDU) is calculated by taking the years needed on average to get the reported degree. In the MS sample and the IT sample the education level is identical: 15.18 years. Again, this provides evidence that the MS sample is comparable to IT workers, as one would expect. Less than 1% of Microsoft professionals are people who attained less than high school **education,** 15% got Master's or Ph.D. degrees, while a modal respondent had a college degree. This is comparable to the CPS IT sample: a modal respondent holds a college diploma, where less then 1% did not receive their high school degree, and about 18% of the sample obtained graduate education. In the full CPS sample the average worker either attended a college but did not complete a degree or holds an associate degree, with 7% of respondents having less than high school education, and only 10% received Master's or Ph.D. degrees.

Ten percent of Microsoft professionals are **females**; this proportion is much higher in the CPS samples: 31% in the CPS IT and 42% in the full CPS sample.

Firm size is known to be correlated with earnings (Schmidt and Zimmermann, 1991; Dunn 1986) and may affect technology adoption and skill distribution of workers (Troske, 1999). However, the firm size categories used in the Microsoft survey differ in important ways from the categories used in the CPS. Specifically, there are 9 more detailed categories in the Microsoft survey instead of 6 in CPS. Additionally, the largest category in CPS, which is "over 1000", puts together a much broader variety of firms while in the Microsoft sample the largest category is "over 100,000". We employed two approaches to reconcile these differences: midpoints and dummies. Using the midpoint of the range has the advantage that it does not require a reconciliation of overlapping categories. However, midpoints are known to give biased slope coefficients due to measurement error. Additionally, it is difficult to come up with a midpoint for largest categories which differ so much. Use of a set of dummy variables also brings about its own problems. Given the distribution by categories in each sample, it is possible to group firms as small (less then 10 employees), medium (10 to 500), large (500 to 1000) and extra large (above 1000). Empirically, the dummy variable approach is less parametric and produces the smallest estimates of the return to certification. The qualitative conclusions appear robust to either specification. We use the dummy variables approach in our results below; the other estimates are available from the authors by request.

The primary variable of our analysis is CERT_MS, an indicator for Microsoft certification. We only observe this variable in the Micro Soft Sample. CERT_MS is equal to zero for all respondents from the CPS Full and the CPS IT samples. Within the MS sample we also observe specific certification (for more detail see Table 3 and the discussion in section V.B.). Among respondents from the Microsoft sample, 11% hold only the simplest certificate, MCP (Microsoft Certified Professional), with a focus on Internet, site building, or an advanced proficiency in different operational systems. About 57% of the respondents indicated MCSE (Microsoft Certified Systems Engineer) to be their highest achievement. This certificate is often mentioned in business reports as one of the most widely recognized technical certifications in the industry. Other credentials include MCSE+I (MCSE with an expertise in Internet), MCDBA (Microsoft Certified Database Administrator), MCSD (Microsoft Certified Solution Developer), and MCT (Microsoft Certified Trainer).

Unfortunately, the Microsoft sample does not include race. Since we have no information about race within the population of Microsoft certified workers, we have chosen not to include race as a covariate. Estimates which include race (coding all MS observations as white) are qualitatively similar to the results found here and are available from the authors by request.

Wage regressions estimated on only the Microsoft sample provide estimates consistent with typical wage regressions. Indeed, they are very similar to the IT sample estimates provided below. As is typically found in samples limited to specific occupations, the return to education within the MS sample is lower than the return to education in the full population: education allows entry into occupations which have higher average earnings such at IT occupations. We discuss this further in section V.

To summarize, MS and CPS IT samples look comparable, while the Full CPS sample differs in expected ways from both of them. An IT professional, on average, is younger, more educated, more likely to be a male, and earns a higher wage than an average worker.

IV. Estimation Issues

The impact of the Microsoft certification on the annual earnings is measured based on the standard Mincerian earnings equation. We use OLS to estimate models of the form

$$W = X\gamma + T\beta + \varepsilon \qquad \textbf{eq. 1}$$

where W is annual earnings, X is a vector of demographic variables, and T is are indicators of Microsoft Certification. The term ε represents the regression errors with the usual assumptions that ε is mean independent of X and T. The indicators in T take two forms: a simple dummy variable for any Microsoft Certification and set of variables representing different types of certificates.

The model is estimated on two samples: all workers, which includes both the MS data and a standard CPS workers sample (as described above); and IT workers, which includes the MS data and only CPS workers who are in IT occupations. Two specifications are estimated: the basic specification includes only age, education, and gender; while the second specification adds a measure of firm size. Two measures of firm size were used: dummy variables and midpoints of ranges. The results were robust to these different approaches. We present only the dummy variable specification, additional results are available from the authors.

Since people from CPS may also have Microsoft certificates which are not measured by the survey, misclassification error in the certification variable is necessarily present. Specifically, instead of T, the true certification indicator, we observe $Z = (1 - C)T$, where C indicates whether a respondent is in the CPS sample. Therefore, for respondents from the Microsoft sample, the certification variable reflects the true status, while for CPS respondents we always observe zeros even when they do hold the certificates. This type of measurement error understates the magnitude of OLS estimates of γ (Aigner, 1971).

A number of authors (Aigner, 1971; Bollinger, 1996, 2001) have considered the implications and corrections for this type of misclassification bias. Bollinger (1996) in particular provides formulas which can be used to correct the bias, if the rates of misclassification are available. In our case, errors of commission (reporting certification when it is not true) are not a concern, and we assume this rate (represented by p, below) to be zero. Errors of omission (represented by q), failure to report certification, occur in 100% of the CPS sample but never in the MS sample. Because aggregate information about numbers of individuals certified is available from Microsoft, estimates of certification rate, and hence response error rates, can be constructed for the sample. The following formula (see Bollinger, 1996) links the bias coefficient $\hat{\beta}$, to the true coefficient β, via the observed rates of certification (P_z) and the error rates (p and q):

$$\beta = (1 - p - q)\frac{(1 - P_Z)P_Z(1 - R_{ZX}^2)}{(P_Z - p)(1 - P_Z - q) - P_Z(1 - P_Z)R_{ZX}^2}\hat{\beta}$$

eq. 2

where R_{ZX}^2 is the determination coefficient from the regression of Z (observed certification) on the other regressors.

In this case, *p*, that is the probability of reporting certification when respondent is not certified, is equal to zero, since we know that everyone from the MS sample is indeed certified. The parameter q here is the proportion of the respondents holding Microsoft certificates that have been misclassified as not certified. Using the definitions of Z (observed certification) and T (true certification) and Bayes Theorem we can write

$$\begin{aligned} q &= \Pr(Z = 0 \mid T = 1) = \Pr(CPS = 1 \mid T = 1) \\ &= \Pr(T = 1 \text{ and } CPS = 1) / P(T = 1) \\ &= \Pr(T = 1 \mid CPS) * \Pr(CPS) / \Pr(T = 1) \end{aligned}$$

eq. 3

The numerator is simply the proportion of people in the CPS we expect to have certification times the proportion of the sample who derive from the CPS. The denominator is the proportion of all observations (Both CPS and MS) for which we expect to have certification. Using Bayesian rule the denominator can be written as:

$$\begin{aligned} P(T = 1) = {} & P(T = 1 \mid CPS = 1) * P(CPS = 1) \\ & + P(T = 1 \mid MS = 1) P(MS = 1) \end{aligned}$$

eq. 4

Since we know the relative sample sizes of the MS and CPS sample and all respondents in the MS sample do have certification (hence P(T=1 | MS=1) = 1), the only unknown is the proportion of people in the CPS sample who have certification.

The proportion of certified individuals in the CPS sample is assumed to be the same as for the entire population since CPS is a representative sample of the whole population. For the CPS IT sample, the proportion is calculated as the ratio of Microsoft certificates to the IT work force. Therefore, based on the numbers reported by Microsoft Corporation and the Bureau of Labor Statistics, the proportions are calculated to be 0.0051 for the Full CPS sample and 0.2276[9] for the CPS IT sample. We then use these figures to correct the OLS estimates. In general, the correction does not affect qualitative conclusions, but does impact the specific estimates. We provide both OLS and measurement error corrected estimates.

Concern does arise that certification may be endogenous. That is, people with higher abilities seek certification. This is a similar argument to the education literature where individuals who are more able seek education. Primarily, this affects our

9 Total employment is taken as 129.7 mln, total employment in the IT sector is estimated to be 2.9 mln, the total number of Microsoft certified individuals is 1.1 mln, and about 60% of them, according to Microsoft, are issued to US residents.

interpretation of the certification: it measure the presence of some kind of human capital. Whether this reflects innate abilities or learning, or both, is not answered directly here. We also note that by examining the return to certification for those individuals who have already selected into IT occupations (the IT sample), we may be at least partially controlling for unobserved heterogeneity: whatever skills and interests lead to those professions are reflected in the intercept. The return to certification among those who have already found employment in IT occupations should isolate the value of that certification after controlling for unobservable characteristics shared by those in IT occupations. Indeed, the difference in the return to certification between the full sample and the IT sample should measure the return to Human Capital that is not specific to Microsoft Certification, but simply specific to demonstrated general computer skills. Thus we contend that the results here shed light on the value, as reflected in the labor market, of skills and abilities associated with computers. It is these characteristics that the labor market values. The fact that the labor market values these skills suggests that simply using computers does not necessarily improve productivity.

V. Empirical Results

Our empirical results are broken into three sections. In the first section we examine the impact of any certificate on earnings. This section is important in establishing the general impact of certification and how that impact differs across specifications. The second section focuses upon the returns to specific certificates. This section highlights that the certification variables can capture different levels of skills and ability. It further suggests that certification is not entirely signaling, since the lowest levels of certification may even reduce earnings. The final section examines the return to certification for specific IT occupations. We find that the return to certification varies by occupation.

A. Overall Return to Certification

Table 2 presents the coefficient on Microsoft certification and education. Four specifications are examined: full sample (CPS + MS samples) with and without controls for firm size and IT sample (CPS IT + MS samples). Full equation estimates are presented in the appendix. Microsoft certification yields a large positive and significant premium in the full sample, while the premium for workers in IT occupations is smaller but still economically and statistically significant. Certification is valuable even within IT occupations. These results are comparable to most previous findings (Entorf and Kramarz, 1996 and Krashinsky, 2000).

Table 2. Coefficient Estimates for Certification Premium

	Full Sample		IT Sample	
	no Firm Size	Firm Size	no Firm Size	Firm Size
MS Certification (OLS)	0.335**	0.287**	0.070**	0.038*
MS Certification (corrected)	0.339**	0.290**	0.092**	0.052*
Education	0.112**	0.109**	0.046**	0.046**

Note: ** - significant at 1%, * - significant at 5%.
Full Results in Appendix Table A1.

The measurement error correction increases the previously calculated returns by as little as 0.005 log points, to as much as 0.031 log points. However, qualitative conclusions are generally robust to this issue. This is not surprising since we do not misclassify many of the people who are trained. There are few MS certified workers in the whole labor force, so the error rate in the Full sample (MS + Full CPS) is small. At the same time, while there are many MS certified people in the IT sector, we do not misclassify many respondents in the IT sample (MS + CPS IT) because the MS sample is a large portion of the full sample. The error of omission (q) is about 3% in both samples. Thus, while the measurement error bias is important in obtaining consistent estimates, it does not substantially change the qualitative conclusions we would draw. Other coefficients in the model show virtually no change due to the measurement error, so we only present the OLS coefficients for education.

The difference between the full sample estimate and the IT estimate ranges from 26.5% to 23.2%. This difference likely measures two aspects. First, it may measure skill bias: if individuals with higher general human capital select into certification. This is so-called skill bias. Certification may be playing a signaling role. Second, it may measure the return to general computer skills. The coefficient on certification in the IT sample measures the specific return to only Microsoft certification in the presence of demonstrated computer skills, and as such may be a cleaner measure of the value added of certification specifically.

A similar coefficient pattern is observed for education. In the full sample estimates, the return to a year of education is 11% (as is typically found). In the IT sample, the return to education falls to 4.6%. Investigation into whether education is mostly signaling (skill bias) or actually has value added have generally found that education actually appears to increase human capital (see for example, Ashenfelter and Krueger, 1994; or Card, 1995). The pattern of lower returns to education within specific occupations is often explained by noting that part of the value of education is access to higher paying occupations. Similarly, one may conclude that part of the value of Microsoft Certification is access to IT occupations. While the difference between the full sample coefficient on Microsoft and the IT sample may reflect skill bias, it also likely reflects a general return to computer skills.

Microsoft Certification and general education have many similarities: hierarchical structure and both are clearly investment in human capital. A college degree typically results in a 40% general increase in earnings. Similarly, the average Microsoft certificate holder gains nearly a 30% return. The typical certificate holder has more than the basic certificate, and as such may have invested substantial time. The MS survey asked respondents the amount of time they spent preparing for their last certificate. The modal response was 6-12 months (29%) while 28% responded that it took 4-6 months. According to Redmondmag.com[10], the average candidate in 1999 spent 377 hours preparing the MCT exams and 226 for MCSD exams. These numbers appear to demonstrate a commitment comparable to many vocational associates' degrees.

The inclusion of firm size characteristics reduces the return to certification by 3-5%. It also reduces the differential between IT and full sample estimates by 1-2. There

10 http://redmondmag.com/SalarySurvey/article.asp?editorialsid=36, http://redmondmag.com/SalarySurvey/article.asp?editorialsid=35 as visited on Oct. 27, 2006

is debate in the literature about what firm size may actually measure. For a survey of these issues see Oi and Idson (1999). As is typically found in the literature, we find that larger firms are associated with higher wages. We also find that, like the Microsoft Certification coefficient, the education coefficient falls slightly. Two possible explanations are particularly important here. The first is that firm size is measuring unobservable skills which larger firms can more readily identify through hiring experience and other mechanisms. Troske (1999) presents evidence that firm size may measure technological advancement: larger firms employ more advanced technology. In using our results to parcel the effect of computer skills on wage into the general return to computer skills and the value added by the specific certificate (above an beyond the mean level of skills), then if firm size measures unobservable skills we should compare the full sample with no firm size variables to the IT sample including firm size variables, thus letting occupation and firm type absorb as much of the unobserved skill component as possible. In contrast, if we believe that firm size measures technology, then we should only use the results where firm size is included in the regression. The difference between results with firm size and those without firm size measures the return to the intersection of computer skills and technology combined. The difference between the two approaches is small, and does not materially effect our conclusions.

B. Returns to Specific Certificates

As discussed in detail above, the certificate program is hierarchical with four separate tracks. We would expect that certificates representing higher levels in the same track would have higher returns. We structure eight dummy variables to reflect this structure: dummies take the value of one when they indicate the individual's highest achievement in the selected track. Certification dummies are mutually exclusive within each track, but they are not mutually exclusive between tracks. For instance, for an individual who reported obtaining MCP, MCP+I, MCP+SB, MCSE, MCSE+I, and MCT certificates, only MCSEI, MCPSB, and MCT dummies are equal to one, while all other five take the value of zero. Table 3 presents the distribution of specific certification dummies in MS sample.

Table 3. Distribution of Certification Dummies by Tracks

Dummy	Number of holders	Distribution by tracks			
		One track	Two tracks	Three tracks	Four tracks
MCP_basic	657	657	0	0	0
MCPI	61	37	19	5	0
MCPSB	119	25	48	40	6
MCSE	3764	2720	712	270	62
MCSEI	1346	715	389	173	69
MCSD	1088	482	238	243	125
MCDBA	1232	45	645	411	131
MCT	909	9[11]	531	238	131
Sample size	6572	4690	1291	460	131

The most popular track, Systems Engineering, attracted 80% of the 6572 individuals in MS sample. Database administrator and Developer tracks are pursued by about 18.3% of the respondents each. About 13.8% of specialists possess credentials of Microsoft certified trainers. There are relatively few individuals whose highest achievement is MCP+I or MCP+SB certificates. This fact can be a reflection of their intermediary status. Noting that tracks are not mutually exclusive, about 70% of the respondents specialize in one path, more than 19% reported that they concentrate on two tracks, while 9% pursue three or more. The vast majority of Microsoft certified IT-professionals pursuing one track hold MCSE and MCSE+I. Approximately half of the respondents who follow two tracks and about 90% of those who pursue three tracks have selected MCDBA.

11 All those respondents reported several basic level MCP certificates, such as MCP developer, Exchange, SMS, SQL. Formally, this is not enough to qualify for MCT according to the requirements above. However, Microsoft changes rules all the time and at some day in the past it could have been sufficient. Misreporting is always a possibility, of course.

Table 4. The Return to Specific Microsoft Certificates.

	OLS Estimates				Corrected Estimates			
	Full Sample		IT Sample		Full Sample		IT Sample	
	no Firm Size	Firms Size	no Firm Size	Firm Size	no Firm Size	Firm Size	no Firm Size	Firm Size
MCP	0.189**	0.140**	-0.120**	-0.136**	0.190**	0.141**	-0.122**	-0.138**
MCPI	0.252**	0.212**	0.027	0.012	0.252**	0.212**	0.027	0.012
MCPSB	0.264**	0.249**	0.175**	0.169**	0.264**	0.249**	0.175**	0.169**
MCSE	0.254**	0.201**	-0.023	-0.040**	0.255**	0.202**	-0.024	-0.041**
MCSEI	0.339**	0.289**	0.081**	0.063**	0.339**	0.289**	0.081**	0.063**
MCSD	0.339**	0.317**	0.218**	0.208**	0.339**	0.317**	0.218**	0.209**
MCDBA	0.009	0.017	0.069**	0.072**	0.009	0.017	0.069**	0.072**
MCT	0.137**	0.148**	0.156**	0.149**	0.137**	0.148**	0.156**	0.149**
Education	0.112**	0.109**	0.034**	0.033**	0.112**	0.109**	0.034**	0.033**

Note: ** - significant at 1%, * - significant at 5%

Full Results in Appendix Table A2

Table 4 presents the returns to specific certificates for our two specifications across our two samples. It is interesting to note that the measurement error correction has very little impact on these estimates. This is largely due to the very small amount of any particular certificate level in the population as a whole, making the under-reporting level in the CPS quite low. The coefficient on MCP, the most basic certificate, in the full sample is about 19% when firm size is not included and 14% when firm size is included. We note that this represents a very basic set of skills. Indeed, the coefficient on MCP in the IT sample is actually a relatively large negative number (12-13%). Clearly computer skills, compared to the average worker, have a relatively high return, but once we control for general computer skills (by limiting to the IT sample) the most basic certificate level represents a lower set of skills relative to the average IT worker.

We next examine the highest certificate levels: MCSEI, MCSD, MCDBA and the highest, MCT. The returns to these for levels in the full sample are (respectively): 33.9%, 33.9%, 1%, and 13.7%. The fact that MCT does not exhibit as high a return as either MCSEI or MCSD is likely due to the fact that 99% of those holding an MCT certificate hold certificates in multiple other tracks and, given the structure, have completed the highest level in at least one of those tracks. Thus in fact, the 13.7% return, unlike the other returns, actually measures the differential between MCT and the average of the returns to the highest certificate in other tracks. Similarly, the nearly zero return to MCDBA may also reflect the fact that approximately 96% of those who hold the

MCDBA certificate hold at least some certificates in other tracks and frequently hold the highest certificate in these other tracks.

We next turn to comparing the returns between the full sample and the IT sample. The most popular track (see Table 3) is the Systems Engineer track. The ordering of the coefficients on MCP, MCPI, MCSE and MCSEI makes sense in both the full and IT samples given the ordering of the certificates. It is interesting to note that the MCSE certificate, while rated above the MCPI certificate, does not appear to have any value in and of itself beyond the MCPI certificate. The return to all certificates in the Systems Engineering track within the IT occupations is lower than the return in the full labor market, similar to our general findings above. Indeed, comparing the full and IT sample coefficients on MCSEI, the highest certificate in the track, suggests that the return to general computer skills are somewhere between 23% and 27%. The return to MCSEI within the IT occupations is a healthy 6 to 8%. Since 77.8% of the Microsoft sample holds the MSCE or MCSEI certificate, this reaffirms and supports the conclusions from the simple specification in section A. Of those holding either the MCSE or MCSEI certificate, roughly 67% hold certificates only in that track. This track has the cleanest interpretation because the results reflect only the return within the track and only this track.

The Developer track also provides very sensible estimates relative to the ordering of the track. As within the Systems Engineer track, here the ordering of the coefficients on MCP, MCPSB, and MCSD makes sense in both samples given the ordering of the certificates. The return to MCSD in the full sample is 31.7% to 33.9% while the return within the IT sample is 20.8% to 21.8%. Here the return to general computer skills appears to be around 13%, lower than the general result or the systems engineering result, but still quite high. We speculate that this may be an understatement since 55% of those who hold the MCSD certificate hold a certificate in at least one other track. The total return for an individual with certification in multiple tracks is the sum across the highest levels in both tracks. The results in this track, while somewhat different from the Systems Engineering track and the general results are still qualitatively similar: there is a large return in the full sample and a more modest return within the IT occupations. The difference between these two returns measures the return to general computing skills.

The Database administrator track poses a number of conundrums. First, in the full sample the return to the MCDBA, advanced certificate, is lower than the return to the basic certificate (MCP). We suspect this is largely due to the fact that the basic certificate can also lead to either the developer or system engineering track and so its return may reflect an expectation of advancement in those tracks (they are more popular). Additionally, less than 1% of the MS sample received only the MCDBA certificate, while 94% of those who hold the MCDBA certificate hold the highest certificate in other tracks. Thus the results here reflect an average of the return to the MCDBA track by itself (with a weight of 1%) and the marginal return of the MCDBA track over one of the two more popular tracks (with a weight of 94%). We suspect this largely explains the lower return of the track in the larger population. Once we control for general computing skills by limiting to the IT sample, the return is more sensible.

We note that of four tracks, none of which are mutually exclusive, only the Database administration track, one of the smallest, presents any major concerns. As we noted above the Trainer track should be considered to measure the average differential of having the training certificate above and beyond at least one other advanced certificate. The fact that less than 1% of the Microsoft sample selected the MCDBA track as a primary choice most likely explains the somewhat confusing results in this track. It should be noted, however, that within the IT sample, the results for this track appear more stable and consistent with theory.

It is interesting to compare these results to the general return to education. A year of education typically returns about 11%. The basic Microsoft Certificate returns nearly 20% in the full sample. Most of the intermediate certificates return over 20%. We might conclude that these certificates result in an educational attainment comparable to the return of an Associates Degree above a HS degree. As noted above, the return to certification in the full sample likely measures three aspects: specific computer skill added from the certificate, general computer skills, skill bias selection. The return to education within the IT industry may be as low as 3.5%. It should also be noted that over 40% of IT workers have a 4-year degree and over 90% have some form of post-secondary education in the IT sample. Within the IT sample, the highest certificates have nearly twice the return to additional education. These certificates, conditional upon having the skills necessary to enter the IT occupations, appear to have a higher rate of return than education in general. This may be a reward to very specific human capital of these certificates as opposed to more general human capital of education.

C. Return to Certification by Occupation

The IT sample presents the clearest picture of the value for the specific skills associated with Microsoft certification. The results for IT workers provide insight into how certification, and hence specific human capital, affects earnings. This is relatively exciting result, since it isolates human capital effects in way that general measures, such as age and education, cannot. One would expect that different occupations within the IT sector would have different values for different specific skills. To investigate this, we now examine the return to certification by the five largest occupations among the IT sample. The IT management occupation was discarded due to small sample size and insufficient variation.

Table 5 presents the return to certification for Programmers, Network Engineers, IT educators, Web Designers and Database Administrators, and IT support occupations. We have estimated the corrected model, but the results are not substantively different than the OLS results. Since the corrections for occupation level regressions require stronger assumptions about population distributions of certificates by occupation, we are more comfortable drawing conclusions from the OLS results. The corrected results are available upon request.

Table 5: Impact of Microsoft Certification by Occupation

	OLS Estimates			
	no Firm Size		Firm Size	
	MS Certification	Education	MS Certification	Education
Programmers	0.191**	0.044**	0.150**	0.044**
Network Engineers	0.035	0.025**	0.063	0.024**
IT Educators	0.155	0.008	0.124	0.010
Web Designers and Database Administrators	0.282**	0.026**	0.278**	0.024**
IT Support	0.088	0.029**	0.092	0.029**

Note: ** - significant at 1%, *- significant at 5%,

Full Results in Appendix Tables A3 and A4.

Within IT occupations, the return to some form of Microsoft Certification ranges from as low as 5.5% for Network Engineers to as high as 35% for Web Design/Database administrator. As one might expect with the necessarily smaller sample sizes, fewer coefficients are significant. There is evidence here that Microsoft certification represents a set of specific skills which may have differing value for different types of IT occupations. It is not surprising that Network Engineers have the lowest return: there are a variety of network solutions, and it is quite likely that those who do not have Microsoft certification have certification in some other type of network administration given that some other certifications (like Novell) have been comparatively popular within this occupation. Thus the low differential may simply reflect that Microsoft skills are not particularly valuable over the other typical skills within this occupation. The large standard errors and the fact that network engineers tend to work at larger firms largely explain the increase in the coefficient when firm size is included.

The highest rate of return is exhibited by Web Designers and Database administrators. It is interesting to note that the coefficient does not change in either a statistically or economically significant way between the two specifications. If firm size is controlling for physical or human capital, there are little differences across firms within this occupation. This is not a surprising result, as one might expect occupations to be specific enough that little variation would exist.

It is interesting to note that 3 of the five occupations exhibit a return to certification on the order of magnitude of 20%. The large standard errors for IT educators are because they have the smallest sample. This is in rather stark contrast to the results in Table 2 for just the IT sector. Network engineers are the largest single group in the IT sample, representing 36%. It seems that the smaller coefficient in the total IT sample (Table 2) may largely be due to the network engineers. Since this may reflect a group with the largest competing certification programs (which we clearly don't account for), this further bolsters the claim that the differential in Tables 2 and 4 measures the return to many different types of computer skills. Indeed, there are few other large certification programs for general skills such as database administration. In this case, Microsoft certification may be the clearest demonstration of these apparently valuable skills.

The rate of return to education also varies across the different occupations, but clearly less dramatically than the return to certification. This finding is consistent with the theory that education is more general human capital while the certificates represent specific types of human capital.

Table 6 presents estimates of the rates of return for specific certificates by occupation. As one might expect, sample size are small and results for this exercise should be taken with caution, but they generally support the idea that specific occupations have differing values for different skill mixes.

Table 6a: The Return to Specific Microsoft Certificates by Occupation (without firm size controls)

	Programmers	Network Engineers	IT Educators	Web Designers and Database Administrators	IT Support
MCP_basic	0.038	-0.110*	0.096	-0.096	0.020
MCPI	-0.018	-0.043	0.190	0.056	-0.036
MCPSB	0.233**	0.111*	0.314*	0.141*	0.168
MCSE	0.080**	-0.022	0.034	-0.001	0.083
MCSEI	0.149**	0.084	0.184	0.046	0.135*
MCDBA	-0.051*	0.036	0.100*	0.096**	0.072
MCSD	0.217**	0.044	0.253**	0.149**	0.220**
MCT	0.099**	0.158**	0.261**	0.119**	0.344**
Education	0.043**	0.021**	0.001	0.021**	0.026**

Note: ** - significant at 1%, *- significant at 5%, measurement error corrected.
Full OLS Results in Appendix Table A5

Table 6b: The Return to Specific Microsoft Certificates by Occupation (including firm size controls)

	Programmers	Network Engineers	IT Educators	Web Designers and Database Administrators	IT Support
MCP_basic	0.001	-0.083	0.147	-0.117	0.034
MCPI	-0.037	-0.030	0.187	0.050	-0.114*
MCPSB	0.190**	0.113**	0.300*	0.149*	0.155
MCSE	0.057*	0.003	0.048	-0.013	0.087
MCSEI	0.127**	0.106*	0.194	0.041	0.127*
MCDBA	-0.049	0.043	0.091*	0.103**	0.086
MCSD	0.191**	0.051	0.228**	0.152**	0.248**
MCT	0.098**	0.156**	0.236**	0.110**	0.329**
Education	0.043**	0.020**	0.003	0.018**	0.026**

Note: ** - significant at 1%, *- significant at 5%, measurement error corrected.
Full OLS Results in Appendix Table A6

We present the OLS results for both specifications in two panels, labeled Table 6a and Table 6b. Similar to the results in Table 5, the correction had little significant impact upon the estimates and so is not presented here. With the exception of IT educators, the basic certificate was nearly zero or negative for all occupations; it was never significant. Web designers and database administrators have the lowest return to the basic certificate (-11.7%), while IT educators actually exhibit a positive return of 14.7% (but with a large standard error).

The highest level certificates, while exhibiting different returns in different occupations, had positive coefficients (with one exception) and were statistically significant in all but 6 of the 20 cases. As noted above, the lack of significance for various certificates to the Network engineers may have to do with competing certificates. It is actually surprising how many coefficients are significant for IT educators, given the small sample.

The results for Programmers and Web Designers and Database Administrators, are interesting to contrast. Programmers have a high return to the MCSEI (systems engineering) certificate and a negative (but insignificant) return to the MCDBA (Database administration) certificate. In contrast, Database Administrators have a positive and significant return to the MCDBA certificate, but a small and insignificant return to the MCSEI certificate. Different skills have different value to different positions in the labor market.

It is not surprising that the coefficient on MCT is the largest for IT educators and IT support personnel: one would expect the returns to being able to teach to be the highest for those who teach. It is similarly unsurprising that the MCSD is highly valuable to Programmers, IT Educators and IT support personnel. MCSD verifies that the worker can create a new product or program from existing products.

The fact that different certificates have different value to different occupations is consistent with the idea that these certificates represent skill attainment. Indeed, the specific certificates may represent very narrow skills in some cases. These results further support the general conclusion that the return in the full population represents an estimate of the overall return of computers skills, and that comparison of those returns to the IT sample may allow us to decompose the return into general computer skills and some kinds of specific skills. Our results are consistent with those found by Krueger (1993), Hamilton (1997), Green (1999) and many others. Our results further explain the empirical findings of Borghans and ter Weel (2001, 2004) if we assume that their "skills" and "sophistication of computer use" questions reflect job requirements and skills match.

VI. Summary and Conclusions

In this paper, we have analyzed the effect of Microsoft certification on earnings of IT workers. The analysis was based on the March 2001 CPS sample of all full-time US workers augmented with a random sample of Microsoft Certified workers. In the full population we found a large positive and significant return to Microsoft Certification., The wage premium may be as high as 33%. As one would expect, the premium fell when the sample was limited to only IT workers. The coefficient in this case represents the value of the Microsoft Certificate to those with some computer skills in general. We interpret the differential between the return in the full sample and the return in the IT sample as measuring a return to general computer skills.

We further examine the return to specific certificates. In general we find the return to higher level certificates is higher than to the basic or intermediate level. This further supports our claims that the certificates are measuring the value of skills.

Finally we examine the returns to certification to specific IT occupations. Some occupations demonstrate a very high return to certification, while other occupations demonstrate a lower return. Many of the occupations demonstrating a lower return have other formal methods of skill attainment and certification, and so the return to the specific Microsoft certificate is lower. We also find that different tracks within the certification process have different, and sensible, values to different occupations. Hence Microsoft certification measures some skill set which is rewarded in the market.

Comparing the returns to MS certification to those of general education, we find that in the full sample the return to some certificates may be as high as the return to an associate's degree. Like the MS Certification, the return to education falls when we limit the sample to only those in IT occupations. Again returns to the highest certificates are comparable to about 2 years of education. The returns to education have less variation across different occupations within the IT sector than do the returns to MS certificates. This comparison suggests that MS Certification does signal specific human capital, while years of education measures more general human capital.

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Web resources:

1. www.microsoft.com
2. www.itaa.org
3. www.idc.com
4. www.certcities.com
5. http://redmondmag.com

Appendix Tables

Table A1: Return to MicroSoft Certification
(Full Results from Table 2 in Text)

	Full Sample		IT Sample	
	Without Firm Size	With Firm Size	Without Firm Size	With Firm Size
Age	0.055**	0.053**	0.052**	0.053**
	(0.002)	(0.002)	(0.004)	(0.004)
Age Squared	-0.00056**	-0.00053**	-0.00061**	-0.00062**
	(0.00003)	(0.00003)	(0.00006)	(0.00006)
Years of Education	0.112**	0.109**	0.046**	0.046**
	(0.001)	(0.001)	(0.003)	(0.003)
Female	-0.337**	-0.358**	-0.147**	-0.151**
	(0.007)	(0.007)	(0.015)	(0.014)
Self Employed		-0.076**		0.182**
		(0.027)		(0.032)
Small Firm		-0.350**		-0.444**
		(0.013)		(0.138)
Medium Firm		-0.080**		-0.020*
		(0.006)		(0.010)
Large Firm		-0.034**		-0.041*
		(0.010)		(0.018)
Micro-Soft Certification	0.335**	0.287**	0.070**	0.038*
	(0.007)	(0.007)	(0.020)	(0.017)
Constant	7.737**	7.893**	9.149**	9.195**
	(0.043)	(0.043)	(0.082)	(0.083)
Observations	49481	49231	7659	7409
R-squared	0.23	0.25	0.10	0.12

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A2: Returns to Specific Certificates
(Full Results from Table 4 in Text)

	Full Sample		IT Sample	
	Without Firm Size	With Firm Size	Without Firm Size	With Firm Size
Age	0.055**	0.053**	0.052**	0.051**
	(0.002)	(0.002)	(0.004)	(0.004)
Age Squared	-0.00056**	-0.00053**	-0.00060**	-0.00060**
	(0.00003)	(0.00003)	(0.00006)	(0.00006)
Years of Education	0.112**	0.109**	0.034**	0.033**
	(0.001)	(0.001)	(0.003)	(0.003)
Female	-0.338**	-0.360**	-0.139**	-0.145**
	(0.007)	(0.007)	(0.014)	(0.014)
Self-Employed		-0.082**		0.105**
		(0.027)		(0.031)
Small Firm		-0.351**		-0.410**
		(0.013)		(0.137)
Medium Firm		-0.084**		-0.052**
		(0.006)		(0.009)
Large Firm		-0.033**		-0.052**
		(0.010)		(0.017)
MCP basic	0.189**	0.140**	-0.120**	-0.136**
	(0.015)	(0.016)	(0.021)	(0.019)
MCPI	0.252**	0.212**	0.027	0.012
	(0.042)	(0.043)	(0.039)	(0.040)
MCPSB	0.264**	0.249**	0.175**	0.169**
	(0.038)	(0.039)	(0.031)	(0.031)
MCSE	0.254**	0.201**	-0.023	-0.040**
	(0.008)	(0.008)	(0.017)	(0.014)
MCSEI	0.339**	0.289**	0.081**	0.063**
	(0.013)	(0.013)	(0.019)	(0.016)
MCDBA	0.009	0.017	0.069**	0.072**
	(0.014)	(0.014)	(0.012)	(0.012)
MCSD	0.339**	0.317**	0.218**	0.208**
	(0.014)	(0.014)	(0.015)	(0.014)
MCT	0.137**	0.148**	0.156**	0.149**
	(0.016)	(0.017)	(0.014)	(0.014)
Constant	7.748**	7.908**	9.343**	9.403**
	(0.043)	(0.043)	(0.080)	(0.081)
Observations	49481	49231	7659	7409
R-squared	0.23	0.25	0.18	0.20

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A3: Return to Certification by IT Occupation
Without Firm Size
(Full Results for Table 5 in Text)

	Programmers	Network engineers	IT educators	Web designers and database administrators	IT support
Age	0.063**	0.044**	0.066**	0.055**	0.025**
	(0.011)	(0.006)	(0.017)	(0.013)	(0.009)
Age Squared	-0.00072**	-0.00050**	-0.00077**	-0.00063**	-0.00027*
	(0.00014)	(0.00008)	(0.00021)	(0.00017)	(0.00012)
Years of Education	0.044**	0.025**	0.008	0.026**	0.029**
	(0.008)	(0.004)	(0.010)	(0.007)	(0.005)
Female	-0.115**	-0.114**	-0.123*	-0.110**	-0.109**
	(0.030)	(0.022)	(0.057)	(0.038)	(0.028)
Micro-Soft Certification	0.191**	0.035	0.155	0.282**	0.088
	(0.025)	(0.050)	(0.413)	(0.105)	(0.050)
Constant	8.957**	9.612**	9.462**	9.223**	9.611**
	(0.184)	(0.125)	(0.437)	(0.230)	(0.184)
Observations	1884	2787	493	684	1047
R-squared	0.11	0.08	0.05	0.11	0.08

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A4: Return to Certification by Occupation
With Firm Size
(Full Results from Table 5 in Text)

	Programmers	Network engineers	IT educators	Web designers and database administrators	IT support
Age	0.064**	0.044**	0.054**	0.055**	0.021*
	(0.010)	(0.006)	(0.017)	(0.013)	(0.010)
Age Squared	-0.00072**	-0.00050**	-0.00066**	-0.00062**	-0.00023
	(0.00013)	(0.00008)	(0.00021)	(0.00017)	(0.00013)
Years of Education	0.044**	0.024**	0.010	0.024**	0.029**
	(0.008)	(0.004)	(0.010)	(0.007)	(0.005)
Female	-0.133**	-0.114**	-0.144*	-0.113**	-0.104**
	(0.028)	(0.022)	(0.059)	(0.041)	(0.029)
Self Employed	0.040	0.098	0.339**	0.146	-0.245**
	(0.088)	(0.051)	(0.058)	(0.091)	(0.068)
Small Firm	-0.411**	-0.001	0.151	0.000	-0.340
	(0.122)	(0.053)	(0.555)	(0.000)	(0.254)
Medium Firm	0.004	-0.113**	-0.007	-0.026	-0.127**
	(0.021)	(0.013)	(0.047)	(0.029)	(0.023)
Large Firm	-0.040	-0.070**	-0.141	-0.048	-0.086*
	(0.042)	(0.024)	(0.074)	(0.043)	(0.038)
Micro-Soft Certification	0.150**	0.063	0.124	0.278**	0.092
	(0.023)	(0.051)	(0.575)	(0.106)	(0.050)
Constant	8.983**	9.656**	9.657**	9.284**	9.733**
	(0.181)	(0.126)	(0.548)	(0.234)	(0.192)
Observations	1855	2687	473	663	977
R-squared	0.14	0.11	0.16	0.12	0.12

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A5: Returns to Specific Certification by IT Occupation
Without Firm Size
(Full Results from Table 6a in Text)

	Programmers	Network engineers	IT educators	Web designers and database administrators	IT support
Age	0.061**	0.043**	0.059**	0.061**	0.024**
	(0.011)	(0.006)	(0.013)	(0.011)	(0.009)
Age Squared	-0.00069**	-0.00048**	-0.00066**	-0.00070**	-0.00027*
	(0.00014)	(0.00008)	(0.00017)	(0.00015)	(0.00012)
Years of Education	0.043**	0.021**	0.001	0.021**	0.026**
	(0.008)	(0.003)	(0.009)	(0.007)	(0.005)
Female	-0.114**	-0.104**	-0.094	-0.109**	-0.102**
	(0.029)	(0.022)	(0.054)	(0.036)	(0.028)
MCP basic	0.037	-0.110*	0.095	-0.096	0.020
	(0.044)	(0.049)	(0.138)	(0.068)	(0.049)
MCPI	-0.018	-0.043	0.189	0.056	-0.036
	(0.078)	(0.078)	(0.147)	(0.074)	(0.070)
MCPSB	0.233**	0.111*	0.314*	0.141*	0.168
	(0.064)	(0.054)	(0.139)	(0.069)	(0.141)
MCSE	0.079**	-0.022	0.033	-0.001	0.082
	(0.025)	(0.046)	(0.096)	(0.039)	(0.048)
MCSEI	0.149**	0.084	0.184	0.046	0.135*
	(0.034)	(0.047)	(0.097)	(0.048)	(0.054)
MCDBA	-0.051*	0.036	0.100*	0.096**	0.072
	(0.024)	(0.024)	(0.042)	(0.028)	(0.048)
MCSD	0.217**	0.044	0.253**	0.149**	0.220**
	(0.022)	(0.057)	(0.064)	(0.036)	(0.079)
MCT	0.099**	0.158**	0.258**	0.119**	0.344**
	(0.034)	(0.025)	(0.048)	(0.045)	(0.109)
Constant	9.013**	9.716**	9.460**	9.357**	9.658**
	(0.182)	(0.121)	(0.276)	(0.205)	(0.186)
Observations	1884	2787	493	684	1047
R-squared	0.13	0.14	0.26	0.18	0.12

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Table A6: Returns to Specific Certificates by IT Occupation With Firm Size
(Full Results from Table 6b in Text)

	Programmers	Network engineers	IT educators	Web designers and database administrators	IT support
Age	0.062**	0.043**	0.052**	0.061**	0.020*
	(0.010)	(0.006)	(0.013)	(0.011)	(0.010)
Age Squared	-0.00069**	-0.00049**	-0.00059**	-0.00070**	-0.00022
	(0.00013)	(0.00008)	(0.00016)	(0.00015)	(0.00013)
Years of Education	0.043**	0.020**	0.003	0.018**	0.026**
	(0.008)	(0.003)	(0.009)	(0.007)	(0.005)
Female	-0.134**	-0.105**	-0.112*	-0.111**	-0.099**
	(0.028)	(0.022)	(0.054)	(0.039)	(0.029)
Self Employed	0.025	0.081	0.214**	0.153	-0.222**
	(0.087)	(0.049)	(0.055)	(0.087)	(0.068)
Small Firm	-0.408**	-0.008	0.277	0.000	-0.344
	(0.122)	(0.049)	(0.149)	(0.000)	(0.256)
Medium Firm	-0.013	-0.113**	-0.035	-0.054	-0.118**
	(0.021)	(0.013)	(0.044)	(0.028)	(0.023)
Large Firm	-0.050	-0.060**	-0.080	-0.059	-0.086*
	(0.042)	(0.023)	(0.067)	(0.042)	(0.037)
MCP basic	0.0005	-0.082	0.146	-0.117	0.034
	(0.046)	(0.051)	(0.150)	(0.071)	(0.050)
MCPI	-0.036	-0.030	0.187	0.050	-0.114*
	(0.073)	(0.083)	(0.162)	(0.083)	(0.057)
MCPSB	0.190**	0.113*	0.300*	0.149*	0.155
	(0.064)	(0.053)	(0.131)	(0.070)	(0.128)
MCSE	0.056*	0.003	0.048	-0.013	0.087
	(0.023)	(0.048)	(0.105)	(0.040)	(0.049)
MCSEI	0.127**	0.106*	0.194	0.041	0.127*
	(0.033)	(0.049)	(0.104)	(0.049)	(0.054)
MCDBA	-0.049*	0.043	0.091*	0.103**	0.086
	(0.024)	(0.023)	(0.042)	(0.028)	(0.049)
MCSD	0.191**	0.051	0.228**	0.152**	0.248**
	(0.022)	(0.058)	(0.067)	(0.037)	(0.073)
MCT	0.098**	0.156**	0.232**	0.110*	0.329**
	(0.034)	(0.025)	(0.050)	(0.044)	(0.113)
Constant	9.046**	9.765**	9.594**	9.448**	9.784**
	(0.179)	(0.123)	(0.272)	(0.212)	(0.194)
Observations	1855	2687	473	663	977
R-squared	0.15	0.17	0.31	0.19	0.16

Robust standard errors in parentheses
* significant at 5%; ** significant at 1%

Certification Requirements Appendix

MCP (Microsoft Certified Professional) is a group of certificates that in 2000 included Microsoft Certified Professionals in operation systems NT4.0 and Windows 2000, developer, exchange, IIs, Site Server, VB, SMS, and SQL. MCP certificates prove that their holders can professionally implement a particular Microsoft product, such as Windows, SQL Server, Exchange Server, FrontPage, Visual Basic, Visual FoxPro, Visual C. To obtain that credential, individuals are required to pass one exam out of the Microsoft list required for any certification track. Normally, an individual is supposed to choose an exam that will apply to the track s/he is intended to continue pursuing. MCP+SB and MCP+I are excluded from this group.

MCP+I (Microsoft Certified Professional with Internet proficiency) verifies that its holder can plan security, install and configure Microsoft server products, manage server resources, extend servers to run CGI scripts or ISAPI scripts, monitor and analyze performance, and troubleshoot problems. To obtain MCP+I certificate an individual had to pass three out of four exams. This credential has been phased out as a part of the move to Windows 2000.

MCP+SB (Microsoft Certified Professional with Site Building proficiency) was designed to validate that its holder can plan, build, maintain and manage sophisticated, interactive Web sites that include database connectivity, multimedia, and searchable content using Microsoft technologies and products. To obtain MCP+SB certificate an individual had to pass two out of three exams. This credential has been phased out as a part of the move to Windows 2000.

MCSE (Microsoft Certified Systems Engineers) confirms that its holder can design and implement an infrastructure solution based on the Windows platform and Microsoft Servers software. The MCSE title requires passing 7 exams - 5 core and 2 elective. The core exams include networking system exams, client operating system and design exams. As an alternative to the elective exam, some other Microsoft or some third-party certifications (such as CompTIA Security+, for example) may be substituted for an MCSE elective. In 2000, an individual could be certified in operating systems NT4.0 or in Windows 2000.

MCDBA (Microsoft Certified Database Administrator) verifies that its holder can design, implement, and administer Microsoft SQL Server databases. The MCDBA title requires passing three core exams (SQL Server design and administration exams and one networking system exam) and one elective exam (to demonstrate the knowledge of a specific Microsoft server product).

MCSD (Microsoft Certified Solution Developers) validates that its holder can design and develop leading-edge business solutions with Microsoft development tools, technologies, platforms, and the Windows architecture. MCSD candidates are required to pass three core exams (solution architecture, desktop applications development, and distributed applications development) and one elective exam.

MCT (Microsoft Certified Trainer) was designed for qualified instructors, certified by Microsoft to deliver Microsoft training courses to IT professionals and developers. An individual who would like to acquire and to sustain the MCT status, every year has to complete an online application, pay an annual fee, and meet a number of program requirements. Those requirements include:

1. maintain current one of the advanced Microsoft certificates: MCSE, MCDBA, or MCSD;
2. pass Microsoft Official Courses and Microsoft Official Workshops, taught by another Microsoft Certified Trainer (MCT) at a Microsoft Certified Technical Education Center (Microsoft CTEC). Another alternative is a trainer readiness course delivered at an IT Academy Regional Center;
3. demonstrate the instructional presentation skills by providing the following credentials:
    a. Certified Technical Trainer (CompTIA CTT+) certification from CompTIA,
    b. a presentation skills or train-the-trainer course that has been pre-approved by Microsoft,
    c. a certified instructor credential from Cisco, Citrix or Novell,
    d. Microsoft Operations Framework (MOF) Trainer certificate.